Method for Bonding Align d Optical Parts and Apparatus thereof

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BACKGROUND OF THE INVENTION

TECHNICAL FIELD

[0001] The present invention relates to a method for bonding one or more aligned optical components to substrates using wedges to minimize any possible alternations to the aligned optical components.

DESCRIPTION OF THE RELATED ART

[0002] Fiber optical networks are becoming increasingly popular for data transmission due to their high speed and high capacity capabilities. There are many optical parts/devices used in the fiber optical networks that require a precise alignment between two elements or among three or more elements. Examples in which such alignments are beneficial include aligning two or more optical elements to achieve best coupling among them.

[0003] A precise alignment between two or more optical elements requires a number of procedures, each of the procedures could be very labor intensive. Once the alignment is done, any alternation or disturbance to the alignment may result in the disqualification of a resultant product using the aligned optical elements. There thus has been a need for an

economic and reliable solution to bonding two or more aligned optical parts to a substrate without affecting the alignment in the optical parts.

SUMMARY OF THE INVENTION

[0004] The present invention, generally speaking, discloses a method for bonding an optical part to a substrate and an optical apparatus using the method, wherein the optical part has been aligned with one or more of other optical parts. One of the advantages and benefits in the present invention is the secure bonding of positions of the optical part with respect to other aligned optical parts. According to one aspect of the present invention, one or more wedges are used to fill in gaps between aligned optical parts and a substrate. Using a bonding agent (e.g. adhesive or solder) to fill in the gaps may induce an alternation or disturbance to the position of the aligned optical parts when the bonding agent is shrank, resulting in a possible misalignment. Using an appropriate material, the wedges are respectively slid in between an aligned optical part and a substrate till respective contacts between the aligned optical part and the wedges are established, a small amount of a bonding agent is then only applied to the respect contacts as well as the contacts between the wedges and the substrate. As a result, the shrinkage that may be caused by the bonding agent to destabilize the aligned optical parts is minimized and the alignments among the optical parts are preserved and can sustain under very high environmental stresses.

[0005] One of the objects in the present invention is to provide a solution to bonding aligned optical parts with one or more substrates without disturbing the alignments.

[0006] Other objects, features, and advantages of the present invention will become apparent upon examining the following detailed description of an embodiment thereof, taken in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings where:

[0008] **Figure 1A** shows a setting in which two optical parts (e.g. collimators) and are being aligned before they are permanently bonded to a substrate to constitute a whole device or part of a device;

[0009] **Figure 1B** shows that a collimator is being positioned by wedges after it is aligned with an optical component or device;

[0010] **Figure 2A** shows a cross-section view of an optical part being positioned by two wedges and bonded to a substrate;

[0011] **Figure 2B** illustrates a wedge having a cross-section being right triangular and being slid towards a cylindrical optical part;

[0012] **Figure 2C** and **2D** show respectively two possible situations in which a wedge may flip over or up an already aligned optical part when being pushed to slide in;

[0013] **Figure 3** shows another setting in which a set of aligned optical parts (only one being shown) are being bonded to a flat substrate; and

[0014] **Figure 4** shows an exemplary setting in which two parallel optical parts are being bonded to a substrate with 4 wedges.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The present invention pertains to a method for bonding two or more aligned optical components using wedges to minimize any possible alternations or disturbance to the alignments in the aligned optical components and an optical apparatus using the method. According to one aspect of the present invention, after two optical parts are aligned, two or more preformed wedges are inserted into gaps between the wedges and a substrate that have been created for aligning the optical parts. As used herein and will be further understood, a preformed wedge is specifically shaped to avoid disturbances to the aligned optical parts when being slid between the optical parts and the substrate. After the wedges are positioned, a small amount of a bonding agent is then applied to only the contacts between the optical parts and the wedges. The wedges are then bonded to the substrate. As a result, the shrinkage that may be caused by the bonding agent to destabilize the aligned optical parts is minimized and the alignment of the optical parts is substantially preserved and can be sustained under very high environmental stresses.

[0016] Reference herein to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment can be included in at least one

embodiment of the invention. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments.

[0017] Referring now to the drawings, in which like numerals refer to like parts throughout the several views. **Figure 1A** shows a setting **100** in which two optical parts (e.g. collimators) **102** and **104** are being aligned before the optical part **102** is permanently bonded to a substrate **106** to constitute a whole device or part of a device. In optical applications, the alignment of two or more optical parts needs to be performed precisely to avoid optical signal loss/distortion. In one exemplary alignment procedure, the optical part **102** is elevated a small distance **108** (i.e. gaps) from the substrate **106** so that adjustment of the optical part **102** can be performed with respect to the optical part or device **104**. Once the alignment of the two optical parts is done, the prior art method is to apply a kind of bonding agent, such as epoxy, to fill in the gaps between the aligned optical part and the substrate. Another prior art method is to fill in the gaps between the aligned optical part and the substrate with solder (or alloy), as a result, a single optical part or an integrated part of an optical device is formed.

[0018] In reality, however, it has been noticed that the filling material, either the bonding agent or the solder, can shrink when it is dried out or cool down, resulting in an undesirable alternation or disturbance to the positions of the originally aligned optical parts.

[0019] According to one aspect of the present invention, the gaps illustrated in **Figur 1A** is not to be filled with any agent, instead, two or

more preformed wedges are used to hold up the originally aligned optical parts when a boding agent is applied. To bond the optical parts to the wedges, a small amount of a bonding agent (e.g. epoxy) is used but only applied to respective contacts between the optical parts and the wedges. Because the amount of the bonding agent is small and the wedges primarily position the optical parts, the alignment of the optical parts is preserved. In fact, the use of the wedges can sustain the alignment under very high environmental stresses (e.g. varying temperatures and vibrations)

[0020] **Figure 1B** shows that a collimator **120** is being positioned by wedges **122** after the collimator **120** has been aligned with an optical component or device **124** (collectively to represent one or more optical parts/devices). The gaps between the collimator **120** and the substrate **126** are created for aligning the collimator **120** with the device **124**. As shown in the figure, the wedges **122** are used to fill in the gaps and at the same time to hold up the positions of the collimator **120** to maintain the alignment.

[0021] Referring now to **Figure 2A**, there is shown a cross-section view of an optical part **206** being positioned by two wedges **202** and **204** and bonded to a substrate **208**. In operation, the optical part **206** (e.g. a collimator) is first aligned with another optical part (not shown). To perform the alignment, one or both of the optical parts are slightly positioned away from the substrate **208** so that one or both of the optical parts can be adjusted appropriately to ensure that both of the optical parts are aligned with each other. Once the alignment is done, the positions of the optical parts shall be preserved. The two wedges **202** and **204** are respectively

slid in from two different directions to hold up the positions of the optical parts when a boding agent is applied. According to one embodiment, a small amount of a bonding agent is applied to only the respective contacts between the contacting surfaces of the optical parts and the wedges. The wedges are then fastened to the substrate by a bonding means (e.g. adhesive, solder, or mechanic fixing).

[0022] According to one embodiment, the cross section **210** of the wedge **212** is shaped as a right triangle, shown in **Figure 2B**. In operation, the wedge is slid in with the sliding face (formed by the hypotenuse of the right triangle) downward to avoid possible flipping over or up the already aligned optical parts as shown respectively in **Figure 2C** and **2D**.

[0023] **Figure 3** shows another setting **300** in which a optical part **304** is being bonded to a flat substrate **302**. Similarly, after the optical part **304** is aligned, two or more wedges **306** and **308** are slid in from two opposite directions to hold up the positions of the aligned optical part. Then a bonding agent is applied to only the contacts between the optical parts **304** and the wedges that are then bonded to substrate **302**.

[0024] Referring now to **Figure 4**, there is shown a setting **400** in which two parallel optical parts **402** and **404** are being bonded to a substrate **406** with 4 wedges **408**, **410**, **412** and **414**. The two parallel optical parts **402** and **404** may have been aligned with respect to each other or with other optical parts. In operation, the wedge **408** may be slid in first and followed by the wedge **410**, which resulting in secured positions of the optical part **402**. To secure the positions of the optical part **404**, the wedge **412** is slid in and followed by the wedge **414**. As such,

both of the optical parts **402** and **404** are now secured without being disturbed. A bonding agent is applied only to the contacts between the optical parts and the wedges.

[0025] **Figure 5** illustrates a configuration or device **500** in which the present invention may be practiced. The device **500** comprises two collimators **502** and **504** and a device **506**, wherein the device **506** is collectively to represent one or more optical parts/devices and functions between the collimators **502** and **504**. In a preferable form, the collimators **502** and **504**, after being aligned, are to be bonded together with a substrate **508**. As illustrated, the gaps between the collimators and the substrate are filled with the wedges (shown as **510** and **512**) contemplated in the present invention, resulting in very stable positions for the aligned the collimators **502** and **504**.

[0026] According to one embodiment of the present invention, the material that is used to make the wedges is preferably from a solid material, for example, glass or metal. However, those skilled in the art will understand that the material selection is not a limitation to the present invention. In fact any material that demonstrates similar characteristics to that of the outside material of optical parts to be bonded may be used. Alternatively, if the resultant devices or parts are to be used in high temperature environment, it is preferably to use a heat-resistant material to avoid any possible material expansion so as to affect the positions of the aligned optical parts.

[0027] The present invention has been described in sufficient detail with a certain degree of particularity. It is understood to those skilled in the art

art that the present disclosure of embodiments has been made by way of examples only and that numerous changes in the arrangement and combination of parts may be resorted without departing from the spirit and scope of the invention as claimed. For example, the two wedges may not be separate pieces, one or both of the two wedges may be integrated with another parts in a resultant optical device. Accordingly, the scope of the present invention is defined by the appended claims rather than the forgoing description of embodiments.